Brief Surgical Procedure Code Lists for Outcomes Measurement and Quality Improvement in Resource-Limited Settings

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Abstract

Conditions amenable to surgery represent a significant portion of the burden of disease worldwide, accounting for 10% of deaths and 14% of disability-adjusted life years lost. Today, however, over five billion people worldwide lack access to safe, timely, and affordable surgical care, and the outcomes experienced by surgical patients are least understood in low- and middle-income countries (LMICs).

An important barrier to improving access to and quality of surgical care in resource-poor settings is the dearth of reliable data, due in part to the lack of a standardized system for classifying surgical procedures. The applicability of existing procedure coding systems in LMIC hospital settings is limited by their size, complexity, and cost of implementation. The coding of surgical procedures has been a particular challenge in Uganda and at Mbarara Regional Referral Hospital (MRRH), a 323-bed hospital and one of the country's busiest surgical centers. A brief procedure code list could improve data collection for administrative, quality improvement, and research purposes at MRRH and in other resource-limited settings.

Here, we describe the creation and validation of three abbreviated surgical procedure code lists at MRRH. We reviewed operating room logbooks to identify all surgical operations performed between January 1 and December 31, 2014. Based on the documented indication for surgery and procedure(s) performed, we assigned each operation up to four procedure codes from the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM), Volume 3. These codes were aggregated to generate procedure code lists. Each surgical procedure was assigned codes by one of two investigators working independently, and a random 20% of procedures were assigned codes by both investigators to evaluate inter-rater reliability.

During the one-year study period, 6464 surgical procedures were performed at MRRH, to which we assigned 435 unique procedure codes. The Kappa statistic representing inter-rater reliability in assignment of codes was 0.7037. 111 procedure codes represented 90% of codes assigned, 180 represented 95%, and 278 represented 98%. These constituted short, intermediate-sized, and long code lists, respectively.

Finally, to validate these procedure code lists, we assessed the ability of each list to describe surgical procedures performed at MRRH during the two-month validation period of August 1 to September 30, 2015. We found that our short, intermediate-sized, and long lists described 83.2%, 89.2%, and 92.6% of procedures performed at MRRH during this time period, respectively.

In conclusion, empirically generated brief procedure code lists based on ICD-9-CM can be used to describe almost all surgical procedures performed at a Ugandan referral hospital. Such a standardized procedure coding system may enable better surgical data collection for research and quality improvement in low-resource setting hospitals.

Glossary

MRRH	Mbarara Regional Referral Hospital
MUST	Mbarara University of Science and Technology
LMICs	low- and middle-income countries
WHO	World Health Organization
CDC	Centers for Disease Control and Prevention
NCHS	National Center for Health Statistics
AMA	American Medical Association
HCUP	Healthcare Cost and Utilization Project
NIS	Nationwide (National) Inpatient Sample
ICD-9	International Classification of Diseases, 9th Revision (WHO) – diagnoses
ICD-10	International Classification of Diseases, 10th Revision (WHO) – diagnoses
ICD-9-CM	International Classification of Diseases, 9th Revision, Clinical Modification (US CDC NCHS) – diagnoses (Volumes 1-2) and procedures (Volume 3)
ICD-10-CM	International Classification of Diseases, 10th Revision, Clinical Modification (US CDC NCHS) – diagnoses
ICD-10-PCS	International Classification of Diseases, 10th Revision, Procedure Coding System (US CDC NCHS) – procedures, used for hospital and inpatient billing
CPT	Current Procedural Terminology (AMA) – procedures, used for physician and outpatient billing
ACS	American College of Surgeons
NSQIP	National Surgical Quality Improvement Program
ICPM	International Classification of Procedures in Medicine (WHO) – discontinued in 1980s
ICHI	International Classification of Health Interventions (WHO) – currently still under development

ACHI	Australian Classification of Health Interventions (Australia)
CCI	Canadian Classification of Health Interventions (Canada)
OPCS-4	Office of Population Censuses and Surveys Classification of Interventions and Procedures, Version 4 (UK)
IHTSDO	International Health Terminology Standards Development Organization
SNOMED CT	Systematized Nomenclature of Medicine Clinical Terminology (IHTSDO)

Introduction

Conditions amenable to surgery represent a significant portion of the burden of disease worldwide,[1] accounting for about 10% of deaths and 14% of disability-adjusted life years lost.[2] The delivery of surgical care is a crucial component of any functioning health care system, given the application of surgery to the prevention, diagnosis, treatment, and palliation of medical disorders in almost every organ system, disease category, and stage of life.[3, 4] Furthermore, essential surgical interventions have been shown to be a cost-effective component of any health system or public health armamentarium, including in resource-poor settings.[5, 6]

Today, however, between two and five billion people worldwide lack access to adequate surgical care, and the gap between surgical need and care is greatest in low- and middle-income countries (LMICs).[7, 8] This gap is due to a multitude of factors, including inadequate human resources for health, infrastructure, and essential medicines and supplies. Notably, another important barrier to improving access to and quality of surgical care in resource-poor settings is the dearth of reliable data due to inadequate information collection and reporting systems. The use of unreliable paper records, relatively low investment in information gathering and research from LMIC health systems, and lack of standardization in describing diagnoses and interventions have recently been identified by several major reports as key factors to be addressed in order to expand access to safe, affordable, and timely surgical care.[8-13]

The Challenge of Surgical Procedure Coding

In particular, one major obstacle to reliable data collection in resource-limited settings is the lack of an internationally standardized classification system for surgical procedures. While the International Classification of Diseases (ICD), maintained by the World Health Organization (WHO) and currently in its 10th iteration (ICD-10), has filled this need for the coding of diagnoses,[14] a corresponding classification system for procedures does not currently exist. The International Classification of Procedures in Medicine (ICPM) was developed by WHO and first published in 1978, but the rapid expansion and evolution of surgical procedures quickly limited its usefulness, and updates to the ICPM were discontinued in the 1980s.[15] Subsequently, several individual countries, primarily high-income, developed their own systems for classifying

procedures, including the United States (CPT and ICD-9-CM Volume 3),[16] Australia (ACHI),[17] Canada (CCI),[18] and the United Kingdom (OPCS-4).[19] International non-governmental organizations have also developed coding systems that encompass procedures, such as the International Health Terminology Standards Development Organization's (IHTSDO) Systematized Nomenclature of Medicine Clinical Terminology (SNOMED CT).[20] Finally, WHO is currently in the process of developing a successor to ICPM called the International Classification of Health Interventions (ICHI). This system is based on the Australian procedure coding system and is intended for use "in countries that do not, as yet, have their own classification of interventions," but it remains incomplete and the timeline for its completion remains unclear.[15]

The complex nomenclature used to describe the various coding systems in use in the US is worth clarifying here, as these names are often misleading and will be referred to in subsequent portions of this thesis.

Diagnosis Codes: As previously described, ICD-10 is maintained by WHO, used worldwide, and has been used in the US to report causes of mortality on death certificates since 1999. In contrast, ICD-10-CM (Clinical Modification) and its predecessor ICD-9-CM Volumes 1 and 2 are US-specific modifications of ICD-10 (and its predecessor ICD-9) used to classify causes of morbidity for the purposes of clinical documentation and billing. ICD-10-CM is maintained by the National Center for Health Statistics (NCHS) and came into effect on October 1, 2015. It replaced ICD-9-CM Volumes 1 and 2, which had been in use from 1979 to 2015.[21]

Procedure Codes: ICD-10-PCS (Procedure Coding System) and its predecessor ICD-9-CM Volume 3 are US-specific procedure coding systems. While given the name "ICD," neither is actually based on any international or WHO-maintained procedure coding system (since none exists). ICD-10-PCS is maintained by the NCHS and replaced ICD-9-CM Volume 3 on October 1, 2015.[22] ICD-10-PCS (and before it, ICD-9-CM Volume 3) is used by hospitals to bill Medicare and private insurers for inpatient procedures, and is also used in surveys administered by the NCHS and large administrative databases such as the Healthcare Cost and Utilization Project (HCUP) Nationwide Inpatient Sample (NIS).[23] In contrast, CPT (Current Procedural

Terminology) is another US-specific procedure coding system maintained by the American Medical Association (AMA) and used by physicians and outpatient centers to bill Medicare and private insurers for procedures and other services.[24] CPT is sometimes also used in certain clinical databases, for example the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP).[25]

In contrast to the United States, however, LMICs seeking to develop their own classification systems for surgical procedures have often been unable due to limited resources.[26] For these countries, implementation of existing procedure code systems is also difficult and impractical due to these systems' large size and complexity and limited clinician time and support staff in these settings. The United States' ICD-9-CM Volume 3, for example, contains 3,824 procedure codes, and its replacement ICD-10-PCS contains 71,924 procedure codes.[22] While this enormous data collection burden is a challenge even in resource-rich settings such as the US, it is outright prohibitive in many LMICs. Reflecting the urgency of this issue, the absence and potential benefits of a coding system for surgical interventions applicable in resource-limited settings were highlighted in the recently published *Lancet* Commission report *Global Surgery 2030*.[8] Other efforts to reduce data collection burden in low-resource settings are underway, such as several studies aiming to develop an efficient risk-adjustment model employing just a few preoperative risk variables to predict mortality and adverse events.[27, 28]

Procedure Coding in Resource-Limited Settings

The classification of surgical procedures has been a particular challenge in Uganda and at Mbarara Regional Referral Hospital (MRRH), a 323-bed public referral hospital located in southwestern Uganda.[29] Uganda is a nation of 36 million people in East Africa, with a Human Development Index rank of 161 out of 187 nations as determined by the United Nations Development Programme.[30] Uganda suffers from a severe shortage of human resources for health care, with about one doctor per 8,300 people,[31] compared to one doctor per 408 people in the United States.[32] Resources for delivering surgical care in Uganda are also limited, with only one surgeon and 0.2 operating rooms per 100,000 people.[33]

MRRH serves a referral population of 4-5 million people, and due to the relatively limited surgical capacity in the health centers and district hospitals in its catchment area, it performs a significant portion of all surgical procedures for the population of southwestern Uganda. To date, however, Uganda and MRRH have had no established system for classifying or coding surgical procedures, making outcomes assessment, quality improvement initiatives, and data reporting to national health authorities difficult to conduct. Specifically, in the absence of procedure codes, it is impossible to describe the case mix at MRRH or other Ugandan hospitals, or to adjust for case mix when assessing quality or comparing outcomes between different hospitals or surgeons. This presented a novel opportunity to empirically develop a concise set of surgical procedure codes based on a review of surgical procedures conducted at MRRH, in order to reduce the data burden prohibiting implementation of such codes in low-resource settings. Here, we present the creation and validation of this procedure code list, which has the potential to improve data collection for administrative, quality improvement, and research purposes at MRRH and in other resource-limited settings.

Methods

Data Collection

All data collection was conducted in person at MRRH during October and November of 2015. We reviewed all four operating theater (operating room) logbooks (the surgery and anesthesia logbooks from the surgical operating theaters, and the ob/gyn and anesthesia logbooks from the ob/gyn operating theaters) to capture all surgical procedures performed during the period January 1 to December 31, 2014. We reasoned that conducting one full year of data collection would allow for (1) capture of seasonal variations in disease incidence, (2) comparison with existing hospital and Ministry of Health data, and (3) comparison with studies in the existing literature (for example, Walker et al., 2010).[34] Variables captured included date of operation, procedure performed, diagnosis/indication for surgery (recorded as one data field in the logbooks), patient age, and patient sex. Medical record number and patient name were also captured solely for the purpose of avoiding record duplication. (Patient name was necessary as some logbook entries lacked a patient record number, and also because multiple patients were sometimes mistakenly assigned the same record number.) Data was de-identified by removing patient record numbers and names prior to data coding and analysis.

We manually entered data from the operating theater logbooks into Microsoft Excel. After medical record number and patient name were reviewed to identify and remove duplicate entries (while retaining multiple operations or reoperations on a single patient on different dates), these patient identifiers were replaced by a study ID that was used for all subsequent analysis.

We obtained surgical procedure codes from the 2009 edition of the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM), Volume 3 – the procedure coding system used by the United States National Center for Health Statistics (NCHS) from 1979 to October 1, 2015.[16] In the absence of an internationally standardized procedure coding system, ICD-9-CM Volume 3 is one of the most widely used publicly accessible set of English-language procedure codes worldwide, and we thus chose it as the basis of our study. CPT (Common Procedural Terminology) codes, in contrast, are maintained privately by the American Medical Association, and a license must be purchased for their use or reprinting in any product or

publication.[35] While ICD-9-CM Volume 3 was replaced in the US by ICD-10-PCS (Procedure Coding System) on October 1, 2015, we chose to use ICD-9-CM procedure codes for three primary reasons. First, the ICD-9-CM procedure codes were fewer in number and thus easier to implement in our study, and the organization of ICD-9-CM codes was also more permissive of accurate code assignment in the context of vague or incompletely specified information (as was the nature of our logbook-derived data). In contrast, ICD-10-PCS codes are far more numerous and specify procedures to a much more granular level, requiring detailed and complete information to achieve accurate code assignment (see Table 1 for examples). Second, we felt that given the more abstract, hexadecimal organization and nomenclature of the ICD-10-PCS codes (as compared to the more intuitive ICD-9-CM codes, illustrated in Table 1), a procedure code list constructed based on ICD-10-PCS codes would be less favorably received and less likely implemented by Ugandan clinicians and hospitals. Finally, almost all currently available US administrative data on surgical procedures use ICD-9-CM rather than ICD-10-PCS codes. We thus felt that basing our code lists on ICD-9-CM codes would allow for more meaningful comparisons between procedures in LMICs coded using our procedure code list and those captured in administrative databases in the US.

Data Coding and Analysis

After data de-identification, each surgical procedure was reviewed by one of two investigators independently. The background and level of training of the two coders were those of a 4th-year American medical student (myself, Charles Liu) and a 2nd-year Ugandan general surgery resident (my Ugandan co-investigator, Peter Kayima). Based on the documented indication for surgery and procedure(s) performed, we assigned each operation up to four ICD-9-CM procedure codes. (Multiple procedure codes were needed in some cases, as surgical operations sometimes involved multiple component procedures, such as exploratory laparotomy and sigmoid colectomy, or open reduction of femur fracture and open reduction of humerus fracture.) Each investigator assigned codes to half of all surgical procedures captured during the study period, and a random 20% of procedures were assigned codes by both investigators.

At the beginning of the data coding process, the two investigators worked together to assign procedure codes to the first 100 surgical procedures, discussing each procedure to reach a

consensus on the most appropriate code(s) to assign. These initial discussions established the basic rules and principles by which both coders subsequently assigned procedure codes, and also established agreed-on norms for which codes to assign in certain ambiguous but frequently encountered situations (e.g. the vague procedure description "surgical toilet and suturing"). Following the assignment of all procedure codes by both coders, the random 20% of procedures assigned codes by both investigators was analyzed using Stata 14 to determine inter-rater reliability between the two investigators. We calculated the Cohen's Kappa statistic, as this value goes beyond simple percentage agreement to assess the percentage agreement above and beyond that expected by chance alone.[36]

Following data collection and coding, ICD-9-CM codes assigned were tabulated using Stata 14 in order to determine the frequency with which each procedure was performed during the study period. For the 20% of procedures coded by both investigators, one investigator's assigned code(s) was chosen at random for each procedure and the other investigator's code(s) discarded for that procedure. The smallest number of ICD-9-CM codes needed to describe at least 90%, 95%, and 98% (rounded to the nearest percent) of surgical cases performed at MRRH during the study period were identified. These constituted three concise procedure code lists (of differing sizes) applicable to classifying surgical procedures at MRRH and in similar settings. In constructing these three code lists, all procedure codes appearing with equal frequency during the study period were either included or excluded as a group from each code list. In other words, if a given procedure code appeared with frequency "n" in the study data and was included in a code list, all other codes with frequency "n" would be included in this code list as well, as there would be no basis on which to include some but not all codes appearing with frequency "n."

Validation

Finally, in order to assess the feasibility and validity of applying the resulting procedure code lists to data collection at MRRH in the future, we conducted a prospective validation analysis. Specifically, we identified all surgical procedures performed at MRRH during August 1 to September 30, 2015, assigned ICD-9-CM codes to these procedures, and determined what percentage of these codes was contained on each of our three procedure code lists. The validation period of August to September 2015 was chosen as it was the most recent two-month period

fully captured in the MRRH operating theater logbooks at the time of data collection in October 2015. Procedures were captured and coded using the same methodology as described above, with codes assigned by just one investigator (myself). The percentage of assigned codes included in each of the three procedure code lists was determined using Microsoft Excel. We hypothesized that the short (90%), intermediate-sized (95%), and long (98%) procedure code lists would capture greater than or equal to 85%, 90%, and 95% of surgical procedures performed during this two-month validation period, respectively.

IRB/Ethical Considerations

This research was granted IRB approval by the Partners Human Research Committee (Protocol #2015P001796). We also secured IRB approval from the Mbarara University of Science and Technology (MUST) Research Ethics Committee, which oversees all research done at MUST and MRRH, and the Uganda National Council for Science and Technology (UNCST), which oversees all human subjects research conducted in the country. Our study involved only retrospective review of medical records (operating theater logbooks) and did not involve any contact with or collection of data from patients. Risk was minimized by de-identifying all data prior to data coding and analysis.

Results

During the one-year study period, 6464 surgical procedures were performed at MRRH, to which we assigned 7623 total and 435 unique procedure codes. (The total number of codes assigned exceeds the number of procedures as a minority of procedures required multiple codes.) 1288 procedures (20%) were chosen randomly to be assigned codes by both investigators independently, and the Kappa statistic representing inter-rater reliability in assignment of codes was 0.7037, corresponding to "substantial" ($0.60<\kappa\leq0.80$) inter-rater reliability.[37] Furthermore, this represents a conservative estimate of inter-rater reliability, as the two investigators were deemed to be in agreement only when they had assigned the exact same number and combination of codes to a given procedure. (For example, if Coder 1 assigned codes A and B, and Coder 2 assigned codes A, B, and C, the coders were deemed to be in disagreement and no partial agreement was registered.)

As shown in Figure 1, 84% of surgical procedures were assigned one procedure code, 14% required two procedure codes, 2% required three procedure codes, and less than 0.1% (n = 17) required four procedure codes. As shown in Figure 2, according to the major divisions of ICD-9-CM, Volume 3, the procedure types most commonly encountered during calendar year 2014 at MRRH were obstetrical procedures (49%, n = 3751), operations on the digestive system (17%, n = 1285), and operations on the female genital organs (12%, n = 932). Also common were operations on the nervous system (5%, n = 342), operations on the musculoskeletal system (4%, n = 336), and operations on the integumentary system, including skin, soft tissue, and breast (4%, n = 299).

Three code lists were generated by aggregating the most commonly assigned procedure codes. As shown in Table 2, 111 procedure codes represented about 90% of codes assigned, 180 represented about 95%, and 278 represented about 98%. These constituted short, intermediate-sized, and long code lists, respectively. Full versions of the code lists can be found in Appendices 1-3, respectively.

As shown in Figure 3, while relatively few procedure codes (111) were needed to capture 90% of all procedures performed during the one-year study period, a comparatively large number of procedure codes was needed for each marginal increase in percent capture of procedures – 69 additional codes to increase percent capture from 90% to 95%, 98 codes to increase percent capture from 95% to 98%, and 157 additional codes to increase percent capture from 98% to 100%. The full relationship between code list length and percent capture of procedures is shown in Figure 4. As shown in the figure, increasing code list length yields diminishing returns as the percent capture approaches 100%.

Finally, to test and validate these procedure code lists, we assessed the ability of each code list to describe surgical procedures performed at MRRH during the two-month validation period of August 1 to September 30, 2015. Specifically, we determined the percent coverage achieved by each code list when applied to the 1665 procedures performed during this period. As shown in Table 2, the short, intermediate, and long procedure code lists described 83.2%, 89.2%, and 92.6% of procedures performed at MRRH during the validation period, respectively.

Discussion

Here, we describe the creation of a brief procedure code list, based on ICD-9-CM, which may have utility in resource-limited settings. Through our validation, we have also demonstrated that such an empirically generated procedure code list can be used to describe almost all surgical procedures performed at a Ugandan referral hospital.

Such a standardized procedure coding system may enable better surgical data collection in resource-constrained hospitals such as MRRH, and has potential applications in administration, quality improvement, and outcomes research. First, in the area of administration, MRRH and all other public Ugandan hospitals are required to report the number of certain major and minor surgical procedures performed each month to the Uganda Ministry of Health through the online Health Management Information System.[38] These data are in turn used to track country-level health trends and to inform allocation of resources to public hospitals. A standardized approach to procedure coding might improve the accuracy and detail of this reporting, which in turn could facilitate improved allocation of resources within the Ugandan public hospital system. This is especially important given that Uganda's health care sector has been documented to be underfunded, with inequitable and fragmented financing that exposes patients and their families to impoverishing expenditures.[39] More broadly, resource allocation in LMICs is often driven by political leverage or incremental budgeting (basing allocations on how resources have always been distributed in the past),[40] and efforts to move toward needs-based allocation are hindered by inadequate data – a problem these code lists will begin to help address.

To give a specific example of this, Mbarara Regional Referral Hospital has for several years been seeking the designation of National Referral Hospital, based on its clinical volume and subspecialty surgical services offered, but it has thus far been unable to make the case for additional resources. Implementation of standardized procedure codes might lead to better characterization of MRRH's patient volume and procedural complexity, facilitating its designation as a National Referral Hospital if warranted. As MRRH is the busiest of the 14 Ugandan regional referral hospitals by surgical volume,[29] and as district hospitals perform fewer and less complex surgical procedures, the procedure code lists described in this thesis are likely

also suitable for use at Uganda's other regional referral and district hospitals. Depending on the extent to which Uganda's National Referral Hospital (Mulago Hospital) performs complex surgeries not seen at MRRH, the lists may also be applicable there.

Second, these surgical procedure code lists have the potential to enable quality improvement (QI) efforts at resource-constrained hospitals in Uganda and beyond, both on an ongoing, day-to-day basis and through more concerted, longer-term QI initiatives. For example, the MRRH surgery department currently does not conduct regularly scheduled morbidity and mortality conferences, and discussion of patient outcomes and how to improve them is hindered by difficulty characterizing the number and types of surgical procedures performed (especially given the large variety of possible procedures). In contrast, for example, the MRRH ob/gyn department more systematically tracks and discusses its maternal mortality events and other bad outcomes, in part because of a national-level focus on lowering maternal mortality, but also because the relatively smaller variety of ob/gyn surgical procedures helps to organize and focus discussions about quality. Implementation of standard procedure codes at hospitals such as MRRH would simplify the complex range of surgical operations performed into a finite and manageable number of procedures for discussion, making it easier to identify operations frequently leading to poor outcomes or associated with marked variation in quality. It would also ensure that comparison of outcomes between hospitals and among clinicians is standardized by comparing outcomes after the same procedure – in other words, by allowing for case mix adjustment. This, in turn, would facilitate the identification and dissemination of best practices.

Third, the procedure code lists described here open the door for more rigorous and impactful surgical outcomes research in resource-limited settings. A basic tenet of outcomes research is risk adjustment, or accounting for different starting levels of risk among patients that may account for observed differences in outcomes (as opposed to true differences in the quality of care provided). An important component of risk adjustment is case mix adjustment, or accounting for patients' diagnoses and (in the case of surgical patients) types of surgical procedures undergone. This adjustment, in turn, is impossible without standardized procedure codes. These code lists thus lay the foundation for case mix- and risk-adjusted outcomes research in resource-constrained settings. Finally, the accurate and thorough identification of relevant

cases in studies of a particular type or types of operation (e.g. appendectomy, cholecystectomy) is also greatly facilitated by standardized procedure codes.

Limitations

This study has several limitations. First, as data collection was conducted at only one study site (MRRH), our study was unable to capture geographic variation in surgical procedures performed and, by definition, has limited generalizability beyond MRRH and Uganda. To optimize the generalizability of our results, however, we chose as our study site MRRH, a regional referral hospital with a large catchment population and subspecialty providers, including neurosurgery, orthopedic surgery, plastic surgery, and pediatric surgery. This allowed us to generate procedure code lists that include a broad range of surgical procedures and have potential applicability in a broad range of hospital settings, including district hospitals and regional referral hospitals in Uganda (which perform a comparable or reduced range of surgical procedures compared to MRRH).

Second, since our data was collected only from hospital operating theater logbooks, the quality of our results was dependent on (and limited by) the quality of information recorded in these logbooks, which was sometimes incomplete, missing, or illegible. To address this limitation, we reviewed both the surgical/ob/gyn provider's logbook and the anesthesia provider's logbook for each operating theater, which allowed us to capture information that was missing from one logbook but present in the other. However, this led to an additional subset of cases in which the two logbooks differed in the listed procedure performed. In these cases, we attempted to make a best determination of the correct procedure based on the listed diagnosis, patient age, and patient sex. In cases where these data fields were unhelpful or unavailable, we resolved conflicts in favor of the surgical/ob/gyn provider's logbook, with the reasoning that these providers performed the procedure and were thus more likely to record it correctly than the anesthetic providers. However, as these cases demonstrate, inconsistent data quality is an inherent limitation of this study.

Finally, since our study period was only one calendar year, some rare procedures that are performed at MRRH less frequently than once per year may not have been captured in our study.

However, the focus of our study was to capture and characterize the most common surgical procedures performed at MRRH, rather than all procedures per se. Furthermore, the procedure code lists generated from the study were created using only the highest frequency 90-98% of surgical procedures performed, meaning the absence of rare procedures did not affect the codes included in these lists.

Suggestions for Future Work

The procedure code lists described here suggest several avenues of future work. First, there is opportunity and need for further validation of the procedure code lists, for example by applying the lists to surgical procedures performed at MRRH over a longer timespan than the two-month validation period described here. Perhaps more importantly, the ultimate utility of these code lists in resource-limited settings depends on the ability of clinicians and other providers to apply them efficiently and accurately in the course of routine documentation. This is a significant challenge, given the high ratio of clinical work to providers in these settings and the lack of support staff to assist with coding. It is precisely these human resource limitations, however, that give these lightweight code lists so much potential utility – if they can be implemented. An important form of validation, therefore, will be testing whether the code lists can be adopted and used by surgeons, obstetricians, and anesthetists under the time constraints of patient care. Inter-rater consistency is also critical to the successful implementation of these code lists – i.e. whether multiple different providers can reliably assign the same codes all or almost all of the time. This would be another important future avenue of inquiry. Closely related to this would be the development of a training curriculum to teach providers how to correctly and reproducibly assign procedure codes, which could be based on existing curricula developed for ICD-9-CM Volume 3.

Going beyond the technical and practical aspects of implementation, an important future step is testing the applicability of these code lists in other, non-Ugandan resource-limited settings. This includes both other LMIC hospitals and resource-constrained hospitals in high-income settings such as the US. Regarding the former, one setting in which suitable data exist is Mozambique, where a collaborative team consisting of surgeons and researchers from the Mozambique Ministry of Health, Universidade Eduardo Mondlane, and the University of California, San

Diego have collaborated to establish a "NSQIP-Lite" surgical outcomes database based on the ACS NSQIP.[41] This database captures records of surgical patients from three hospitals in geographically dispersed regions of Mozambique, has been in operation since 2013, and includes fields such as "diagnosis" and "name/type of surgery" that would allow application of the procedure code lists described here. Applying the code lists to data from Mozambique would allow for a true test of the principle that lists developed using single-country data can be broadly utilized in other resource-limited settings. As Dr. John Rose, one of the key leaders of the NSQIP-Lite database team in Mozambique, is currently a surgical resident at Harvard, we hope to be able to reach out and collaborate on this endeavor in the future.

Finally, a third and exciting opportunity for future work lies in using the data collected in this study to compare surgical case mix at MRRH with that at resource-constrained US hospitals, for example those in rural or remote parts of the country. While rural US hospitals are part of the American health care system, they nevertheless face many of the same challenges as LMIC hospitals: resource limitations, geographically disperse patient populations, and competing pressures to treat vs. refer patients with complex surgical pathology. Furthermore, data on the burden of surgically treatable disease are available from both the US and most LMICs, through data sources such as the Institute for Health Metrics and Evaluation (IHME) Global Burden of Disease (GBD) Study (which have already been used to model global surgical need).[42] Therefore, comparing case mix and case volume at MRRH with that at rural US hospitals, and taking into account differences in the burden of surgical disease in the two locations, might allow us to identify gaps in access to certain surgical procedures in Uganda or the rural US, and provide new perspective on the differences in met surgical need between high- and low-income country settings. Specifically, the HCUP Nationwide Inpatient Sample (NIS) contains data from hundreds of rural US hospitals and utilizes ICD-9-CM procedure codes,[23] which we have also chosen to use in our study. Using NIS data, we could thus match selected US rural hospitals to MRRH based on number of beds and number of surgical procedures performed per year, allowing comparison of case mix and volume. Since it is possible to interpret the same data as either lack of access to a surgical procedure at one site (e.g. MRRH) with overuse of that same surgical procedure at the other site (e.g. US hospital), we could consider designating a certain country's surgical rate for a given condition as the "ideal" surgical rate. For example, this has

been done by existing studies in the literature, using surgical rates from New Zealand as the "gold standard" or ideal rate.[42]

Conclusion

A standard approach to classifying surgical procedures in resource-limited hospitals is critical to improving data collection, resource allocation, and ultimately patient care in these settings. Without a list of procedure codes both comprehensive enough to describe the vast majority of operations performed and concise enough to be feasibly implemented despite time and human resource constraints, quality improvement and outcomes research are severely limited, if not impossible. Rather than attempting to create an entirely new procedure coding system, or choosing which existing codes to include in a code list using expert opinion alone, we chose here to begin with the American ICD-9-CM procedure coding system and to empirically determine which codes appear commonly enough to warrant inclusion in a concise code list. The output of this work, three procedure code lists containing 111, 180, and 278 procedure codes, respectively, lays the foundation for systematic coding of surgical procedures in low-resource settings. With the future directions outlined above and other outgrowths of this work, we hope these code lists will become clinical and research tools used to improve surgical care and quality of life for patients worldwide.

Summary

There is currently no internationally standardized system for classifying surgical procedures. This poses a major challenge to data gathering in resource-limited settings such as Uganda, since coding systems for surgical procedures developed in high-resource settings are too expensive and impractical to implement given very limited financial resources for health and the lack of support personnel. Here, we describe the creation of a lightweight procedure coding system that could begin to address this gap. By reviewing one year's worth of operating room logbook data at Mbarara Regional Referral Hospital in southwestern Uganda and assigning American procedure codes from a classification system called ICD-9-CM, we were able to generate three short procedure code lists of 111, 180, and 278 codes that describe almost all surgeries performed at this Ugandan hospital. We were then able to test these three code lists on more recent data obtained from the hospital, which confirmed their ability to capture the vast majority of surgeries done. These concise procedure code lists represent a first step toward better characterizing met and unmet surgical need in resource-poor settings, and begin to lay the groundwork for efforts to improve quality of surgical care for patients worldwide.

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Tables and Figures

Table 1. Illustrative differences between ICD-9-CM and ICD-10-PCS procedure codes.

Common Procedure Name	ICD-9-CM Code	Possible ICD-10-PCS Codes
Appendectomy	47.09 Other appendectomy	0DTJ0ZZ Resection of Appendix, Open Approach
Cesarean section	74.99 Other cesarean section of unspecified type	10D00Z0 Extraction of Products of Conception, Classical, Open Approach 10D00Z1 Extraction of Products of Conception, Low Cervical, Open Approach 10D00Z2 Extraction of Products of Conception, Extraperitoneal, Open Approach
Open reduction and internal fixation of femur	79.35 Open reduction of fracture with internal fixation, femur	0QS604Z Reposition Right Upper Femur with Internal Fixation Device, Open Approach 0QS704Z Reposition Left Upper Femur with Internal Fixation Device, Open Approach 0QS804Z Reposition Right Femoral Shaft with Internal Fixation Device, Open Approach 0QS904Z Reposition Left Femoral Shaft with Internal Fixation Device, Open Approach 0QSB04Z Reposition Right Lower Femur with Internal Fixation Device, Open Approach 0QSC04Z Reposition Left Lower Femur with Internal Fixation Device, Open Approach
Wound debridement	86.28 Nonexcisional debridement of wound, infection or burn	0JD00ZZ Extraction of Scalp Subcutaneous Tissue and Fascia, Open Approach 0JD10ZZ Extraction of Face Subcutaneous Tissue and Fascia, Open Approach 0JD40ZZ Extraction of Anterior Neck Subcutaneous Tissue and Fascia, Open Approach 0JD50ZZ Extraction of Posterior Neck Subcutaneous Tissue and Fascia, Open Approach 0JD60ZZ Extraction of Chest Subcutaneous Tissue and Fascia, Open Approach 0JD70ZZ Extraction of Back Subcutaneous Tissue and Fascia, Open Approach 0JD80ZZ Extraction of Abdomen Subcutaneous Tissue and Fascia, Open Approach 0JD90ZZ Extraction of Buttock Subcutaneous Tissue and Fascia, Open Approach 0JDB0ZZ Extraction of Perineum Subcutaneous Tissue and Fascia, Open Approach 0JDC0ZZ Extraction of Pelvic Region Subcutaneous Tissue and Fascia, Open Approach 0JDD0ZZ Extraction of Right Upper Arm Subcutaneous Tissue and Fascia, Open Approach 0JDF0ZZ Extraction of Left Upper Arm Subcutaneous Tissue and Fascia, Open Approach 0JDG0ZZ Extraction of Right Lower Arm Subcutaneous Tissue and Fascia, Open Approach 0JDH0ZZ Extraction of Left Lower Arm Subcutaneous Tissue and Fascia, Open Approach 0JDJ0ZZ Extraction of Right Hand Subcutaneous Tissue and Fascia, Open Approach 0JDK0ZZ Extraction of Left Hand Subcutaneous Tissue and Fascia, Open Approach 0JDL0ZZ Extraction of Right Upper Leg Subcutaneous Tissue and Fascia, Open Approach 0JDM0ZZ Extraction of Left Upper Leg Subcutaneous Tissue and Fascia, Open Approach 0JDN0ZZ Extraction of Right Lower Leg Subcutaneous Tissue and Fascia, Open Approach 0JDP0ZZ Extraction of Left Lower Leg Subcutaneous Tissue and Fascia, Open Approach 0JDQ0ZZ Extraction of Right Foot Subcutaneous Tissue and Fascia, Open Approach 0JDR0ZZ Extraction of Left Foot Subcutaneous Tissue and Fascia, Open Approach

Table 2. Characteristics of the three procedure code lists generated.

List Name	Number of Codes	Frequency Cutoff for Code Inclusion	% of Procedures Captured in Study Period (2014)	% of Procedures Captured in Prospective Validation (8-9/2015)
Short	111	≥ 8	90.0%	83.2%
Intermediate	180	≥ 4	94.9%	89.2%
Long	278	≥ 2	97.9%	92.6%

Figure 1. Number of codes needed to describe each surgical procedure.

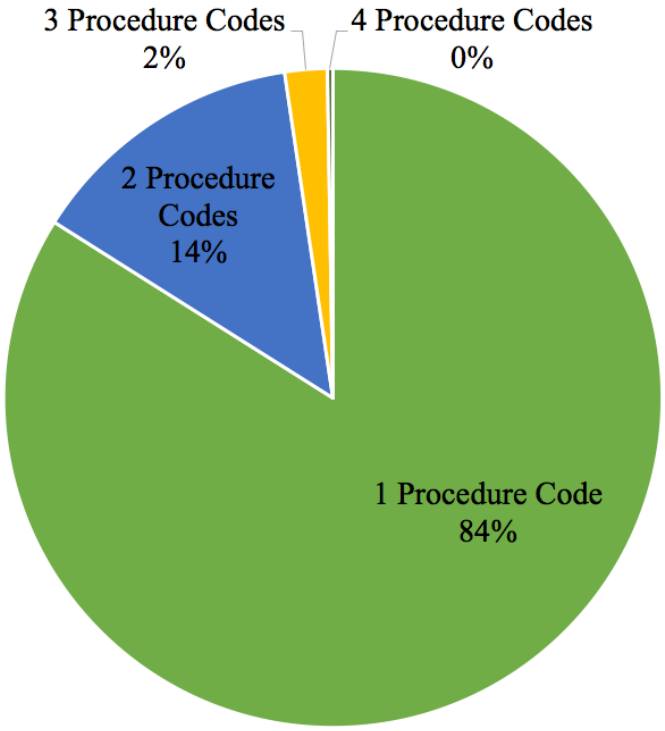


Figure 2. Procedure codes assigned by organ system (major divisions of ICD-9-CM, Volume 3).

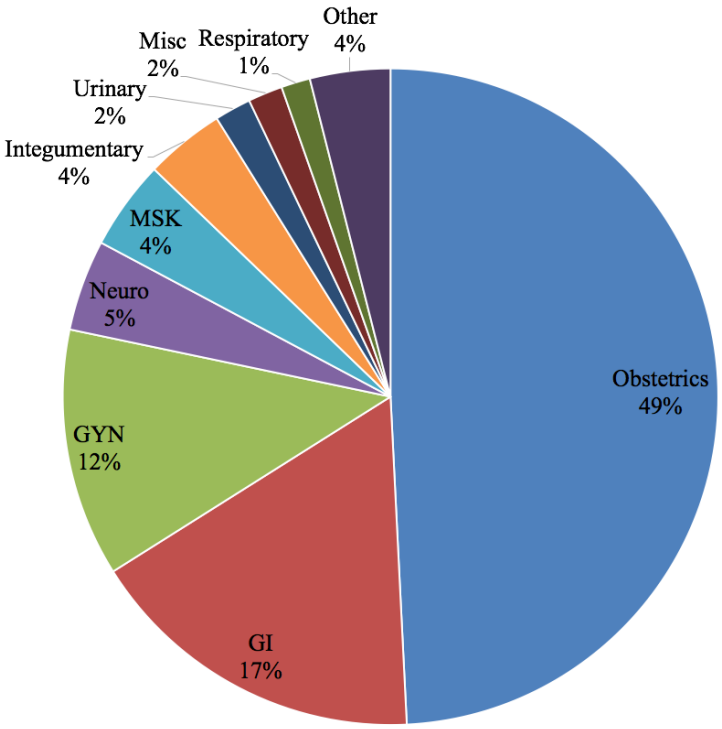


Figure 3. Marginal increase in code list length needed to achieve higher percent capture.

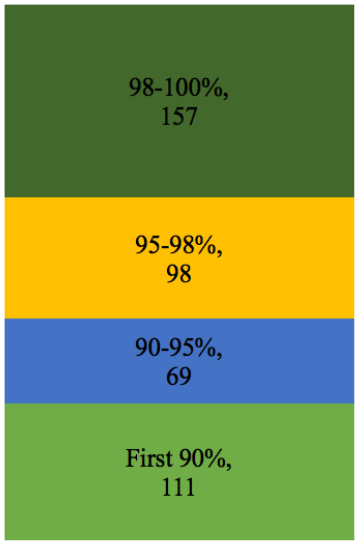
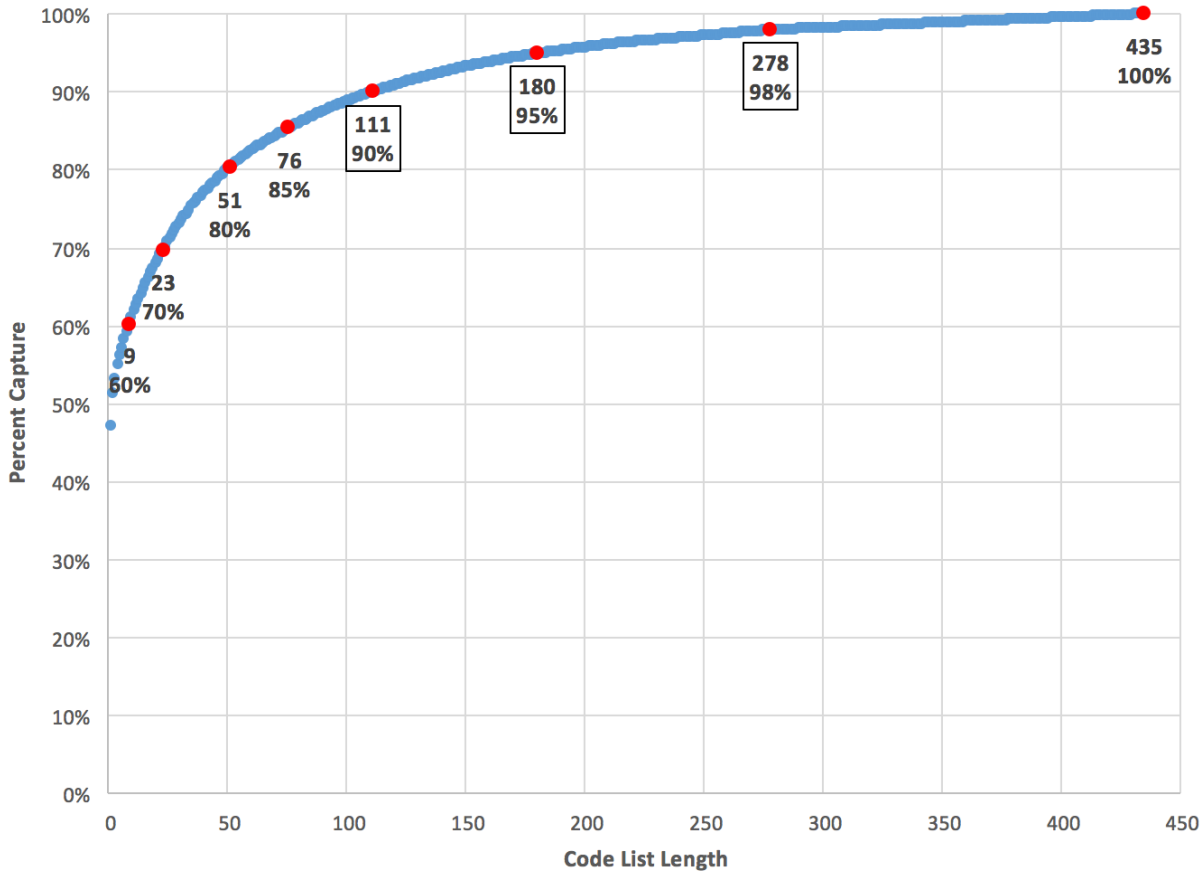


Figure 4. Relationship between code list length and percent capture of procedures.



Appendices

Appendix 1. Short (111-code) surgical procedure code list.

Procedure code	Frequency
1. OPERATIONS ON THE NERVOUS SYSTEM (01-05)	
01.24 Other craniotomy	136
01.25 Other craniectomy	13
01.31 Incision of cerebral meninges	82
02.02 Elevation of skull fracture fragments	9
02.12 Other repair of cerebral meninges	15
02.34 Ventricular shunt to abdominal cavity and organs	23
03.09 Other exploration and decompression of spinal canal	27
03.52 Repair of spinal myelomeningocele	11
2. OPERATIONS ON THE ENDOCRINE SYSTEM (06-07)	
06.4 Complete thyroidectomy	8
06.7 Excision of thyroglossal duct or tract	8
5. OPERATIONS ON THE NOSE, MOUTH, AND PHARYNX (21-29)	
21.31 Local excision or destruction of intranasal lesion	9
27.54 Repair of cleft lip	10
28.2 Tonsillectomy without adenoidectomy	8
28.3 Tonsillectomy with adenoidectomy	20
6. OPERATIONS ON THE RESPIRATORY SYSTEM (30-34)	
31.1 Temporary tracheostomy	13
31.42 Laryngoscopy and other tracheoscopy	26
31.43 Closed [endoscopic] biopsy of larynx	10
33.22 Fiber-optic bronchoscopy	10
33.23 Other bronchoscopy	31
8. OPERATIONS ON THE HEMIC AND LYMPHATIC SYSTEM (40-41)	
40.11 Biopsy of lymphatic structure	23
41.5 Total splenectomy	37
9. OPERATIONS ON THE DIGESTIVE SYSTEM (42-54)	
42.23 Other esophagoscopy	21
43.19 Other gastrostomy	38
44.39 Other gastroenterostomy	24
44.41 Suture of gastric ulcer site	24
45.62 Other partial resection of small intestine	30
45.73 Open and other right hemicolectomy	13
45.76 Open and other sigmoidectomy	26
45.79 Other and unspecified partial excision of large intestine	16
45.90 Intestinal anastomosis, not otherwise specified	24
45.91 Small-to-small intestinal anastomosis	40
45.93 Other small-to-large intestinal anastomosis	19
46.10 Colostomy, not otherwise specified	37
46.20 Ileostomy, not otherwise specified	22
46.51 Closure of stoma of small intestine	9
46.52 Closure of stoma of large intestine	23
46.73 Suture of laceration of small intestine, except duodenum	55
46.80 Intra-abdominal manipulation of intestine, not otherwise specified	13
47.09 Other appendectomy	44
47.2 Drainage of appendiceal abscess	9

51.22 Cholecystectomy	19
53.00 Unilateral repair of inguinal hernia, not otherwise specified	78
53.49 Other open umbilical herniorrhaphy	17
53.59 Repair of other hernia of anterior abdominal wall	11
54.11 Exploratory laparotomy	309
54.12 Reopening of recent laparotomy site	22
54.19 Other laparotomy	52
54.23 Biopsy of peritoneum	11
54.4 Excision or destruction of peritoneal tissue	11
54.59 Other lysis of peritoneal adhesions	28
54.61 Reclosure of postoperative disruption of abdominal wall	42
54.74 Other repair of omentum	16
10. OPERATIONS ON THE URINARY SYSTEM (55-59)	
55.51 Nephroureterectomy	13
57.18 Other suprapubic cystostomy	10
57.81 Suture of laceration of bladder	14
57.84 Repair of other fistula of bladder	37
11. OPERATIONS ON THE MALE GENITAL ORGANS (60-64)	
61.2 Excision of hydrocele (of tunica vaginalis)	9
62.5 Orchiopexy	15
64.0 Circumcision	9
12. OPERATIONS ON THE FEMALE GENITAL ORGANS (65-71)	
65.21 Marsupialization of ovarian cyst	15
65.29 Other local excision or destruction of ovary	12
65.39 Other unilateral oophorectomy	39
65.49 Other unilateral salpingo-oophorectomy	51
65.61 Other removal of both ovaries and tubes at same operative episode	52
66.39 Other bilateral destruction or occlusion of fallopian tubes	79
66.62 Salpingectomy with removal of tubal pregnancy	68
67.19 Other diagnostic procedures on cervix	92
67.59 Other repair of internal cervical os	10
67.61 Suture of laceration of cervix	11
68.29 Other excision or destruction of lesion of uterus	21
68.39 Other and unspecified subtotal abdominal hysterectomy	55
68.49 Other and unspecified total abdominal hysterectomy	149
68.59 Other and unspecified vaginal hysterectomy	44
68.69 Other and unspecified radical abdominal hysterectomy	14
69.09 Other dilation and curettage	14
69.59 Other aspiration curettage of uterus	27
70.29 Other diagnostic procedures on vagina and cul-de-sac	9
70.50 Repair of cystocele and rectocele	12
70.51 Repair of cystocele	30
70.73 Repair of rectovaginal fistula	13
70.77 Vaginal suspension and fixation	29
71.23 Marsupialization of Bartholin's gland (cyst)	11
13. OBSTETRICAL PROCEDURES (72-75)	
74.3 Removal of extratubal ectopic pregnancy	8
74.99 Other cesarean section of unspecified type	3597
75.4 Manual removal of retained placenta	17
75.51 Repair of current obstetric laceration of cervix	10
75.52 Repair of current obstetric laceration of corpus uteri	9
75.62 Repair of current obstetric laceration of rectum and sphincter ani	52

75.69 Repair of other current obstetric laceration	44
14. OPERATIONS ON THE MUSCULOSKELETAL SYSTEM (76-84)	
77.07 Sequestrectomy, tibia and fibula	14
79.06 Closed reduction of fracture without internal fixation, tibia and fibula	12
79.35 Open reduction of fracture with internal fixation, femur	40
79.66 Debridement of open fracture site, tibia and fibula	12
81.05 Dorsal and dorsolumbar fusion, posterior technique	17
81.52 Partial hip replacement	8
83.09 Other incision of soft tissue	11
83.21 Biopsy of soft tissue	14
83.49 Other excision of soft tissue	18
84.17 Amputation above knee	15
15. OPERATIONS ON THE INTEGUMENTARY SYSTEM (85-86)	
85.21 Local excision of lesion of breast	10
85.41 Unilateral simple mastectomy	12
86.04 Other incision with drainage of skin and subcutaneous tissue	73
86.22 Excisional debridement of wound, infection, or burn	54
86.28 Nonexcisional debridement of wound, infection or burn	47
86.3 Other local excision or destruction of lesion or tissue of skin and subcutaneous tissue	17
86.59 Closure of skin and subcutaneous tissue of other sites	57
86.60 Free skin graft, not otherwise specified	12
16. MISCELLANEOUS DIAGNOSTIC AND THERAPEUTIC PROCEDURES (87-99)	
89.26 Gynecological examination	11
98.02 Removal of intraluminal foreign body from esophagus without incision	31
98.11 Removal of intraluminal foreign body from ear without incision	13
98.15 Removal of intraluminal foreign body from trachea and bronchus without incision	31

Appendix 2. Intermediate-sized (180-code) surgical procedure code list.

Procedure code	Frequency
1. OPERATIONS ON THE NERVOUS SYSTEM (01-05)	
01.24 Other craniotomy	136
01.25 Other craniectomy	13
01.31 Incision of cerebral meninges	82
01.59 Other excision or destruction of lesion or tissue of brain	6
02.02 Elevation of skull fracture fragments	9
02.12 Other repair of cerebral meninges	15
02.2 Ventriculostomy	6
02.34 Ventricular shunt to abdominal cavity and organs	23
03.09 Other exploration and decompression of spinal canal	27
03.51 Repair of spinal meningocele	4
03.52 Repair of spinal myelomeningocele	11
2. OPERATIONS ON THE ENDOCRINE SYSTEM (06-07)	
06.39 Other partial thyroidectomy	5
06.4 Complete thyroidectomy	8
06.7 Excision of thyroglossal duct or tract	8
4. OPERATIONS ON THE EAR (18-20)	
18.21 Excision of preauricular sinus	7
18.29 Excision or destruction of other lesion of external ear	7
19.4 Myringoplasty	4
20.51 Excision of lesion of middle ear	4
5. OPERATIONS ON THE NOSE, MOUTH, AND PHARYNX (21-29)	
21.31 Local excision or destruction of intranasal lesion	9
27.54 Repair of cleft lip	10
28.0 Incision and drainage of tonsil and peritonsillar structures	6
28.2 Tonsillectomy without adenoidectomy	8
28.3 Tonsillectomy with adenoidectomy	20
29.11 Pharyngoscopy	7
29.12 Pharyngeal biopsy	5
6. OPERATIONS ON THE RESPIRATORY SYSTEM (30-34)	
31.1 Temporary tracheostomy	13
31.42 Laryngoscopy and other tracheoscopy	26
31.43 Closed [endoscopic] biopsy of larynx	10
33.22 Fiber-optic bronchoscopy	10
33.23 Other bronchoscopy	31
34.02 Exploratory thoracotomy	7
34.04 Insertion of intercostal catheter for drainage	6
8. OPERATIONS ON THE HEMIC AND LYMPHATIC SYSTEM (40-41)	
40.11 Biopsy of lymphatic structure	23
40.21 Excision of deep cervical lymph node	7
41.5 Total splenectomy	37
9. OPERATIONS ON THE DIGESTIVE SYSTEM (42-54)	
42.23 Other esophagoscopy	21
43.19 Other gastrostomy	38
44.15 Open biopsy of stomach	5
44.39 Other gastroenterostomy	24
44.41 Suture of gastric ulcer site	24
45.62 Other partial resection of small intestine	30
45.73 Open and other right hemicolectomy	13

45.76 Open and other sigmoidectomy	26
45.79 Other and unspecified partial excision of large intestine	16
45.90 Intestinal anastomosis, not otherwise specified	24
45.91 Small-to-small intestinal anastomosis	40
45.93 Other small-to-large intestinal anastomosis	19
45.94 Large-to-large intestinal anastomosis	6
46.01 Exteriorization of small intestine	5
46.03 Exteriorization of large intestine	6
46.10 Colostomy, not otherwise specified	37
46.20 Ileostomy, not otherwise specified	22
46.21 Temporary ileostomy	4
46.39 Other enterostomy	4
46.51 Closure of stoma of small intestine	9
46.52 Closure of stoma of large intestine	23
46.73 Suture of laceration of small intestine, except duodenum	55
46.80 Intra-abdominal manipulation of intestine, not otherwise specified	13
46.81 Intra-abdominal manipulation of small intestine	5
47.09 Other appendectomy	44
47.2 Drainage of appendiceal abscess	9
48.25 Open biopsy of rectum	5
48.79 Other repair of rectum	7
49.29 Other diagnostic procedures on anus and perianal tissue	5
49.79 Other repair of anal sphincter	6
50.12 Open biopsy of liver	6
50.61 Closure of laceration of liver	6
51.22 Cholecystectomy	19
51.32 Anastomosis of gallbladder to intestine	6
53.00 Unilateral repair of inguinal hernia, not otherwise specified	78
53.49 Other open umbilical herniorrhaphy	17
53.59 Repair of other hernia of anterior abdominal wall	11
53.9 Other hernia repair	7
54.0 Incision of abdominal wall	6
54.11 Exploratory laparotomy	309
54.12 Reopening of recent laparotomy site	22
54.19 Other laparotomy	52
54.23 Biopsy of peritoneum	11
54.29 Other diagnostic procedures on abdominal region	4
54.4 Excision or destruction of peritoneal tissue	11
54.59 Other lysis of peritoneal adhesions	28
54.61 Reclosure of postoperative disruption of abdominal wall	42
54.71 Repair of gastroschisis	6
54.72 Other repair of abdominal wall	4
54.74 Other repair of omentum	16
10. OPERATIONS ON THE URINARY SYSTEM (55-59)	
55.51 Nephroureterectomy	13
57.18 Other suprapubic cystostomy	10
57.41 Transurethral lysis of intraluminal adhesions	5
57.81 Suture of laceration of bladder	14
57.84 Repair of other fistula of bladder	37
58.29 Other diagnostic procedures on urethra and periurethral tissue	4
58.43 Closure of other fistula of urethra	5
58.45 Repair of hypospadias or epispadias	7

58.46 Other reconstruction of urethra	4
58.49 Other repair of urethra	7
11. OPERATIONS ON THE MALE GENITAL ORGANS (60-64)	
61.2 Excision of hydrocele (of tunica vaginalis)	9
62.3 Unilateral orchiectomy	4
62.5 Orchiopexy	15
64.0 Circumcision	9
12. OPERATIONS ON THE FEMALE GENITAL ORGANS (65-71)	
65.21 Marsupialization of ovarian cyst	15
65.29 Other local excision or destruction of ovary	12
65.39 Other unilateral oophorectomy	39
65.49 Other unilateral salpingo-oophorectomy	51
65.61 Other removal of both ovaries and tubes at same operative episode	52
66.39 Other bilateral destruction or occlusion of fallopian tubes	79
66.62 Salpingectomy with removal of tubal pregnancy	68
67.19 Other diagnostic procedures on cervix	92
67.39 Other excision or destruction of lesion or tissue of cervix	4
67.59 Other repair of internal cervical os	10
67.61 Suture of laceration of cervix	11
68.29 Other excision or destruction of lesion of uterus	21
68.39 Other and unspecified subtotal abdominal hysterectomy	55
68.49 Other and unspecified total abdominal hysterectomy	149
68.59 Other and unspecified vaginal hysterectomy	44
68.69 Other and unspecified radical abdominal hysterectomy	14
68.9 Other and unspecified hysterectomy	6
69.02 Dilation and curettage following delivery or abortion	7
69.09 Other dilation and curettage	14
69.41 Suture of laceration of uterus	5
69.59 Other aspiration curettage of uterus	27
70.29 Other diagnostic procedures on vagina and cul-de-sac	9
70.50 Repair of cystocele and rectocele	12
70.51 Repair of cystocele	30
70.73 Repair of rectovaginal fistula	13
70.77 Vaginal suspension and fixation	29
71.11 Biopsy of vulva	5
71.23 Marsupialization of Bartholin's gland (cyst)	11
71.3 Other local excision or destruction of vulva and perineum	7
71.71 Suture of laceration of vulva or perineum	4
71.79 Other repair of vulva and perineum	4
13. OBSTETRICAL PROCEDURES (72-75)	
74.3 Removal of extratubal ectopic pregnancy	8
74.99 Other cesarean section of unspecified type	3597
75.4 Manual removal of retained placenta	17
75.51 Repair of current obstetric laceration of cervix	10
75.52 Repair of current obstetric laceration of corpus uteri	9
75.61 Repair of current obstetric laceration of bladder and urethra	4
75.62 Repair of current obstetric laceration of rectum and sphincter ani	52
75.69 Repair of other current obstetric laceration	44
14. OPERATIONS ON THE MUSCULOSKELETAL SYSTEM (76-84)	
77.00 Sequestrectomy, unspecified site	5
77.05 Sequestrectomy, femur	4
77.07 Sequestrectomy, tibia and fibula	14

78.15 Application of external fixator device, femur	7
79.02 Closed reduction of fracture without internal fixation, radius and ulna	4
79.06 Closed reduction of fracture without internal fixation, tibia and fibula	12
79.31 Open reduction of fracture with internal fixation, humerus	7
79.35 Open reduction of fracture with internal fixation, femur	40
79.36 Open reduction of fracture with internal fixation, tibia and fibula	6
79.39 Open reduction of fracture with internal fixation, other specified bone	5
79.65 Debridement of open fracture site, femur	4
79.66 Debridement of open fracture site, tibia and fibula	12
80.16 Other arthrotomy, knee	5
81.05 Dorsal and dorsolumbar fusion, posterior technique	17
81.52 Partial hip replacement	8
82.45 Other suture of other tendon of hand	4
83.09 Other incision of soft tissue	11
83.14 Fasciotomy	4
83.21 Biopsy of soft tissue	14
83.39 Excision of lesion of other soft tissue	5
83.49 Other excision of soft tissue	18
83.64 Other suture of tendon	6
84.01 Amputation and disarticulation of finger	4
84.15 Other amputation below knee	6
84.17 Amputation above knee	15
84.3 Revision of amputation stump	6
15. OPERATIONS ON THE INTEGUMENTARY SYSTEM (85-86)	
85.21 Local excision of lesion of breast	10
85.41 Unilateral simple mastectomy	12
86.04 Other incision with drainage of skin and subcutaneous tissue	73
86.22 Excisional debridement of wound, infection, or burn	54
86.28 Nonexcisional debridement of wound, infection or burn	47
86.3 Other local excision or destruction of lesion or tissue of skin and subcutaneous tissue	17
86.59 Closure of skin and subcutaneous tissue of other sites	57
86.60 Free skin graft, not otherwise specified	12
16. MISCELLANEOUS DIAGNOSTIC AND THERAPEUTIC PROCEDURES (87-99)	
89.26 Gynecological examination	11
93.51 Application of plaster jacket	7
93.54 Application of splint	7
93.57 Application of other wound dressing	4
98.02 Removal of intraluminal foreign body from esophagus without incision	31
98.11 Removal of intraluminal foreign body from ear without incision	13
98.13 Removal of intraluminal foreign body from pharynx without incision	7
98.15 Removal of intraluminal foreign body from trachea and bronchus without incision	31

Appendix 3. Long (278-code) surgical procedure code list.

Procedure code	Frequency
1. OPERATIONS ON THE NERVOUS SYSTEM (01-05)	
01.14 Open biopsy of brain	2
01.24 Other craniotomy	136
01.25 Other craniectomy	13
01.31 Incision of cerebral meninges	82
01.39 Other incision of brain	2
01.59 Other excision or destruction of lesion or tissue of brain	6
02.02 Elevation of skull fracture fragments	9
02.12 Other repair of cerebral meninges	15
02.2 Ventriculostomy	6
02.34 Ventricular shunt to abdominal cavity and organs	23
03.09 Other exploration and decompression of spinal canal	27
03.51 Repair of spinal meningocele	4
03.52 Repair of spinal myelomeningocele	11
03.53 Repair of vertebral fracture	3
2. OPERATIONS ON THE ENDOCRINE SYSTEM (06-07)	
06.2 Unilateral thyroid lobectomy	3
06.39 Other partial thyroidectomy	5
06.4 Complete thyroidectomy	8
06.7 Excision of thyroglossal duct or tract	8
07.63 Partial excision of pituitary gland, unspecified approach	3
3. OPERATIONS ON THE EYE (08-16)	
11.51 Suture of corneal laceration	2
4. OPERATIONS ON THE EAR (18-20)	
18.09 Other incision of external ear	3
18.21 Excision of preauricular sinus	7
18.29 Excision or destruction of other lesion of external ear	7
19.4 Myringoplasty	4
20.01 Myringotomy with insertion of tube	3
20.21 Incision of mastoid	2
20.49 Other mastoidectomy	3
20.51 Excision of lesion of middle ear	4
5. OPERATIONS ON THE NOSE, MOUTH, AND PHARYNX (21-29)	
21.31 Local excision or destruction of intranasal lesion	9
22.19 Other diagnostic procedures on nasal sinuses	3
22.2 Intranasal antrotomy	2
22.39 Other external maxillary antrotomy	2
22.63 Ethmoidectomy	2
25.51 Suture of laceration of tongue	2
26.29 Other excision of salivary gland lesion	3
26.32 Complete sialoadenectomy	3
27.54 Repair of cleft lip	10
27.62 Correction of cleft palate	2
28.0 Incision and drainage of tonsil and peritonsillar structures	6
28.2 Tonsillectomy without adenoidectomy	8
28.3 Tonsillectomy with adenoidectomy	20
28.6 Adenoidectomy without tonsillectomy	2
29.11 Pharyngoscopy	7
29.12 Pharyngeal biopsy	5

6. OPERATIONS ON THE RESPIRATORY SYSTEM (30-34)	
31.1 Temporary tracheostomy	13
31.42 Laryngoscopy and other tracheoscopy	26
31.43 Closed [endoscopic] biopsy of larynx	10
33.22 Fiber-optic bronchoscopy	10
33.23 Other bronchoscopy	31
34.02 Exploratory thoracotomy	7
34.04 Insertion of intercostal catheter for drainage	6
34.82 Suture of laceration of diaphragm	3
8. OPERATIONS ON THE HEMIC AND LYMPHATIC SYSTEM (40-41)	
40.11 Biopsy of lymphatic structure	23
40.21 Excision of deep cervical lymph node	7
40.3 Regional lymph node excision	2
41.33 Open biopsy of spleen	2
41.5 Total splenectomy	37
9. OPERATIONS ON THE DIGESTIVE SYSTEM (42-54)	
42.23 Other esophagoscopy	21
43.19 Other gastrostomy	38
43.3 Pyloromyotomy	2
43.7 Partial gastrectomy with anastomosis to jejunum	3
44.15 Open biopsy of stomach	5
44.39 Other gastroenterostomy	24
44.41 Suture of gastric ulcer site	24
44.42 Suture of duodenal ulcer site	3
44.61 Suture of laceration of stomach	2
45.00 Incision of intestine, not otherwise specified	2
45.26 Open biopsy of large intestine	2
45.62 Other partial resection of small intestine	30
45.73 Open and other right hemicolectomy	13
45.75 Open and other left hemicolectomy	2
45.76 Open and other sigmoidectomy	26
45.79 Other and unspecified partial excision of large intestine	16
45.90 Intestinal anastomosis, not otherwise specified	24
45.91 Small-to-small intestinal anastomosis	40
45.93 Other small-to-large intestinal anastomosis	19
45.94 Large-to-large intestinal anastomosis	6
46.01 Exteriorization of small intestine	5
46.03 Exteriorization of large intestine	6
46.10 Colostomy, not otherwise specified	37
46.11 Temporary colostomy	2
46.20 Ileostomy, not otherwise specified	22
46.21 Temporary ileostomy	4
46.39 Other enterostomy	4
46.51 Closure of stoma of small intestine	9
46.52 Closure of stoma of large intestine	23
46.73 Suture of laceration of small intestine, except duodenum	55
46.74 Closure of fistula of small intestine, except duodenum	3
46.75 Suture of laceration of large intestine	2
46.80 Intra-abdominal manipulation of intestine, not otherwise specified	13
46.81 Intra-abdominal manipulation of small intestine	5
46.93 Revision of anastomosis of small intestine	3
47.09 Other appendectomy	44

47.2 Drainage of appendiceal abscess	9
48.24 Closed [endoscopic] biopsy of rectum	2
48.25 Open biopsy of rectum	5
48.29 Other diagnostic procedures on rectum, rectosigmoid and perirectal tissue	2
48.40 Pull-through resection of rectum, not otherwise specified	2
48.69 Other resection of rectum	2
48.71 Suture of laceration of rectum	3
48.79 Other repair of rectum	7
49.29 Other diagnostic procedures on anus and perianal tissue	5
49.46 Excision of hemorrhoids	3
49.79 Other repair of anal sphincter	6
49.99 Other operations on anus	2
50.0 Hepatotomy	2
50.12 Open biopsy of liver	6
50.61 Closure of laceration of liver	6
51.22 Cholecystectomy	19
51.32 Anastomosis of gallbladder to intestine	6
51.36 Choledochoenterostomy	2
51.43 Insertion of choledochohepatic tube for decompression	2
52.12 Open biopsy of pancreas	3
53.00 Unilateral repair of inguinal hernia, not otherwise specified	78
53.02 Other and open repair of indirect inguinal hernia	2
53.29 Other unilateral femoral herniorrhaphy	2
53.49 Other open umbilical herniorrhaphy	17
53.59 Repair of other hernia of anterior abdominal wall	11
53.61 Other open incisional hernia repair with graft or prosthesis	2
53.9 Other hernia repair	7
54.0 Incision of abdominal wall	6
54.11 Exploratory laparotomy	309
54.12 Reopening of recent laparotomy site	22
54.19 Other laparotomy	52
54.23 Biopsy of peritoneum	11
54.29 Other diagnostic procedures on abdominal region	4
54.4 Excision or destruction of peritoneal tissue	11
54.59 Other lysis of peritoneal adhesions	28
54.61 Reclosure of postoperative disruption of abdominal wall	42
54.71 Repair of gastroschisis	6
54.72 Other repair of abdominal wall	4
54.74 Other repair of omentum	16
10. OPERATIONS ON THE URINARY SYSTEM (55-59)	
55.24 Open biopsy of kidney	3
55.51 Nephroureterectomy	13
56.74 Ureteroneocystostomy	3
57.18 Other suprapubic cystostomy	10
57.32 Other cystoscopy	2
57.41 Transurethral lysis of intraluminal adhesions	5
57.81 Suture of laceration of bladder	14
57.84 Repair of other fistula of bladder	37
57.89 Other repair of bladder	3
57.94 Insertion of indwelling urinary catheter	2
58.1 Urethral meatotomy	2
58.29 Other diagnostic procedures on urethra and periurethral tissue	4

58.43 Closure of other fistula of urethra	5
58.45 Repair of hypospadias or epispadias	7
58.46 Other reconstruction of urethra	4
58.47 Urethral meatoplasty	2
58.49 Other repair of urethra	7
11. OPERATIONS ON THE MALE GENITAL ORGANS (60-64)	
61.0 Incision and drainage of scrotum and tunica vaginalis	2
61.2 Excision of hydrocele (of tunica vaginalis)	9
62.3 Unilateral orchiectomy	4
62.41 Removal of both testes at same operative episode	2
62.5 Orchiopexy	15
63.73 Vasectomy	3
64.0 Circumcision	9
12. OPERATIONS ON THE FEMALE GENITAL ORGANS (65-71)	
65.21 Marsupialization of ovarian cyst	15
65.29 Other local excision or destruction of ovary	12
65.39 Other unilateral oophorectomy	39
65.49 Other unilateral salpingo-oophorectomy	51
65.61 Other removal of both ovaries and tubes at same operative episode	52
66.39 Other bilateral destruction or occlusion of fallopian tubes	79
66.4 Total unilateral salpingectomy	3
66.62 Salpingectomy with removal of tubal pregnancy	68
67.12 Other cervical biopsy	2
67.19 Other diagnostic procedures on cervix	92
67.39 Other excision or destruction of lesion or tissue of cervix	4
67.59 Other repair of internal cervical os	10
67.61 Suture of laceration of cervix	11
68.21 Division of endometrial synechiae	2
68.29 Other excision or destruction of lesion of uterus	21
68.39 Other and unspecified subtotal abdominal hysterectomy	55
68.49 Other and unspecified total abdominal hysterectomy	149
68.59 Other and unspecified vaginal hysterectomy	44
68.69 Other and unspecified radical abdominal hysterectomy	14
68.9 Other and unspecified hysterectomy	6
69.02 Dilation and curettage following delivery or abortion	7
69.09 Other dilation and curettage	14
69.41 Suture of laceration of uterus	5
69.52 Aspiration curettage following delivery or abortion	2
69.59 Other aspiration curettage of uterus	27
69.7 Insertion of intrauterine contraceptive device	2
70.29 Other diagnostic procedures on vagina and cul-de-sac	9
70.33 Excision or destruction of lesion of vagina	3
70.50 Repair of cystocele and rectocele	12
70.51 Repair of cystocele	30
70.52 Repair of rectocele	2
70.62 Vaginal reconstruction	2
70.73 Repair of rectovaginal fistula	13
70.77 Vaginal suspension and fixation	29
70.92 Other operations on cul-de-sac	3
71.11 Biopsy of vulva	5
71.23 Marsupialization of Bartholin's gland (cyst)	11
71.3 Other local excision or destruction of vulva and perineum	7

71.71 Suture of laceration of vulva or perineum	4
71.79 Other repair of vulva and perineum	4
13. OBSTETRICAL PROCEDURES (72-75)	
73.59 Other manually assisted delivery	2
73.6 Episiotomy	2
74.1 Low cervical cesarean section	2
74.3 Removal of extratubal ectopic pregnancy	8
74.91 Hysterotomy to terminate pregnancy	2
74.99 Other cesarean section of unspecified type	3597
75.4 Manual removal of retained placenta	17
75.51 Repair of current obstetric laceration of cervix	10
75.52 Repair of current obstetric laceration of corpus uteri	9
75.61 Repair of current obstetric laceration of bladder and urethra	4
75.62 Repair of current obstetric laceration of rectum and sphincter ani	52
75.69 Repair of other current obstetric laceration	44
14. OPERATIONS ON THE MUSCULOSKELETAL SYSTEM (76-84)	
77.00 Sequestrectomy, unspecified site	5
77.05 Sequestrectomy, femur	4
77.07 Sequestrectomy, tibia and fibula	14
77.09 Sequestrectomy, other bones	2
77.60 Local excision of lesion or tissue of bone, unspecified site	3
77.65 Local excision of lesion or tissue of bone, femur	3
77.85 Other partial ostectomy, femur	2
78.15 Application of external fixator device, femur	7
78.17 Application of external fixator device, tibia and fibula	3
78.60 Removal of implanted devices from bone, unspecified site	2
79.01 Closed reduction of fracture without internal fixation, humerus	3
79.02 Closed reduction of fracture without internal fixation, radius and ulna	4
79.06 Closed reduction of fracture without internal fixation, tibia and fibula	12
79.25 Open reduction of fracture without internal fixation, femur	2
79.31 Open reduction of fracture with internal fixation, humerus	7
79.32 Open reduction of fracture with internal fixation, radius and ulna	3
79.35 Open reduction of fracture with internal fixation, femur	40
79.36 Open reduction of fracture with internal fixation, tibia and fibula	6
79.39 Open reduction of fracture with internal fixation, other specified bone	5
79.65 Debridement of open fracture site, femur	4
79.66 Debridement of open fracture site, tibia and fibula	12
79.71 Closed reduction of dislocation of shoulder	3
79.85 Open reduction of dislocation of hip	2
80.16 Other arthrotomy, knee	5
81.00 Spinal fusion, not otherwise specified	3
81.02 Other cervical fusion, anterior technique	2
81.05 Dorsal and dorsolumbar fusion, posterior technique	17
81.44 Patellar stabilization	3
81.46 Other repair of the collateral ligaments	2
81.52 Partial hip replacement	8
82.45 Other suture of other tendon of hand	4
83.09 Other incision of soft tissue	11
83.14 Fasciotomy	4
83.21 Biopsy of soft tissue	14
83.39 Excision of lesion of other soft tissue	5
83.49 Other excision of soft tissue	18

83.64 Other suture of tendon	6
84.01 Amputation and disarticulation of finger	4
84.07 Amputation through humerus	3
84.10 Lower limb amputation, not otherwise specified	2
84.11 Amputation of toe	2
84.12 Amputation through foot	2
84.15 Other amputation below knee	6
84.17 Amputation above knee	15
84.3 Revision of amputation stump	6
15. OPERATIONS ON THE INTEGUMENTARY SYSTEM (85-86)	
85.21 Local excision of lesion of breast	10
85.41 Unilateral simple mastectomy	12
86.04 Other incision with drainage of skin and subcutaneous tissue	73
86.09 Other incision of skin and subcutaneous tissue	2
86.11 Biopsy of skin and subcutaneous tissue	2
86.22 Excisional debridement of wound, infection, or burn	54
86.26 Ligation of dermal appendage	2
86.28 Nonexcisional debridement of wound, infection or burn	47
86.3 Other local excision or destruction of lesion or tissue of skin and subcutaneous tissue	17
86.59 Closure of skin and subcutaneous tissue of other sites	57
86.60 Free skin graft, not otherwise specified	12
86.84 Relaxation of scar or web contracture of skin	3
86.89 Other repair and reconstruction of skin and subcutaneous tissue	3
16. MISCELLANEOUS DIAGNOSTIC AND THERAPEUTIC PROCEDURES (87-99)	
87.65 Other x-ray of intestine	2
89.26 Gynecological examination	11
93.51 Application of plaster jacket	7
93.54 Application of splint	7
93.57 Application of other wound dressing	4
97.02 Replacement of gastrostomy tube	2
98.02 Removal of intraluminal foreign body from esophagus without incision	31
98.11 Removal of intraluminal foreign body from ear without incision	13
98.13 Removal of intraluminal foreign body from pharynx without incision	7
98.14 Removal of intraluminal foreign body from larynx without incision	2
98.15 Removal of intraluminal foreign body from trachea and bronchus without incision	31
98.29 Removal of foreign body without incision from lower limb, except foot	2